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Evaluation of the Residual Effect of Cattle Manure Combinations with Inorganic Fertilizer and Chemical Weed Control on the Sustainability of Chewing Sugarcane Production at Badeggi Southern Guinea Savanna of Nigeria

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Abstract: The residual effect of fertility rates (cattle manure with inorganic fertilizer rates) was not significant on percent sand, silt and clay in 2004-2005, 2005-2006 and 2006-2007 trials. However In the three trials, the effect of residual fertility rates was significant on percent organic carbon, organic matter and cat ion exchange capacity (CEC) with the least value been obtained from the untreated control, followed by the separately applied inorganic and organic fertilizers. The application of main treatments had a significant residual effect on weed, sugarcane growth parameters and its stalk yield. Plots treated with combined application of cattle manure with inorganic fertilizer at all rates gave better performance of weeds, growth parameters and yield than plots treated with separate application of 10t/ha cattle manure and 120kgN/ha - 26kgP/ha -37kgK/ha inorganic fertilizer. The residual effect from the application of herbicides, hoe - weeding and the weedy check non- significant on weed control, sugarcane growth parameters and stalk yield.

Key words: Manure · Inorganic Fertilizer · Residual effect · Chewing Sugarcane Growth and yield parameters

INTRODUCTION

Manures, in the wide sense refers to all substances added to the soil in order to increase the supply of plant nutrients [1]. The application of organic manures has the aim of increasing soil fertility and thus productivity, but the effect of the addition depends partly on the existing fertility of soil. According to Gupta *et al*. [2], the effect varies according to the inherent physical and chemical properties of the soil particularly on the nature and content all together helps in improving soil structure, soil aeration and therefore, improving the activities of soil micro-organisms [3]. And soils into which FYM has been incorporated contain enough soluble phosphoric acid, potash and lime [4]. Organic matter supplies most of the nitrogen, sulphur and half phosphorus needed by unfertilized crops [5]. Dung contains the undigested portion of the feed eaten by animal, whereas urine contains only the soluble products and has higher nitrogen and potassium contents than dung and since these are in solution, they are quickly available to plant [6]. Long term use of cow-dung increased aggregate stability, pore space, bulk density and available water range [7]. A great part of the virtue of animal manures lies in their slow mineralization and the addition of organic matter to the soil, which they produced, offers a definite advantage over soluble fertilizers [8]. Gupta *et al*. [2] found that the yield of sugarcane was significantly influenced by organic matter, cat ion exchange capacity and pH of soil as a result of cow dung incorporated. Greater efficiency of manure is obtained when applied in small amounts and more often [9]. In long term manuring experiment on a permanent plot in India, Rayer [10] observed from soil depths of 0-15cm and 15-30cm less variation in their levels of pH, organic carbon, total nitrogen, exchangeable calcium and magnesium indicating some sort of stabilization in the equilibrium, although the availability of Mn, Zn and Cu in the soil increased.

Cow-dung increases the efficiency of mineral fertilizers by improving properties of the soil [7]. Cow-dung applied with inorganic nitrogen (N), increased soil pH and ameliorated acidity [3]. The continuous application of cow-dung at 60 t ha^{-1} for ten years on sugarcane field proved superior over the application of annual in organic fertilizer at the rate of 120N - 16P_2O_5 - 160K_2O kg/ ha alone [11]. They associated this to increased soil organic carbon, organic nitrogen and exchangeable calcium, thereby resulting in a significant increase of sugarcane yield. Combined application of cow-dung at 20 and 10 t ha^{-1} with 50 kg N ha^{-1} increased yield production of successive cane cropping [12].

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The objective of these trials was to evaluate the possibility of residual nutrients from the application of cattle manure combined with inorganic fertilizer and chemical weed control in sustaining the production of chewing sugar cane.

MATERIALS AND METHOD

The three years Ph.D terminated research trial on the influence of cattle manure combinations with inorganic fertilizer and chemical weed control on weed, growth and yield of sugar cane established on the upland sugarcane experimental field of the National Cereals Research Institute Badeggi (Lat. 9°45′N, Long.06°07′E, 70.5 metres above sea level in the Southern Guinea Savanna ecological zone of Nigeria from 2004 - 2007 wet and dry seasons were evaluated for their residual effect on the sustainability of sugarcane production at Badeggi in the southern Guinea Savanna of Nigeria. The soil of the experimental site has been classified as ultisol and sandy loam in texture with bulk density of 1.49m^{-1} [13]. It has an average annual rainfall of 1124mm and mean temperature 23°C - 33°C respectively. Details of physico-chemical properties of the soil and analysis of the cattle dung during the periods of experiment are presented in Tables 1 -2. The treatments evaluated for their residual effect on sugarcane production consisted of seven fertility rates and four weed control measures. The treatment therefore include: - F_0 = control (no cattle dung, no inorganic fertilizer), F_1 = 120kgN/ha – 26kgP/ha - 37kgK/ha alone (NCRI recommended rate for sole sugarcane, F_2 = 10tonnes/ha of air dried cattle dung (NCRI recommended rate), F_3 = 10tonnes/ha of air dried cattle dung + 120kgN/ha – 26kgP/ha -37kgK/ha

F_4 = 10tonnes/ha of air dried cattle dung + 60kgN/ha - 13kgP/ha - 18.7kgK/ha

F_5 = 5tonnes/ha of air dried cattle dung + 120kgN/ha - 26kgP/ha -37kgK/ha

and F_6 = 5tonnes/ha of air dried cattle dung + 60kgN/ha - 13kgP/ha - 18.7kgK/ha constituted the main plot, while the weed control treatments W_0 = Weedy check, W_1 = hoe weeding at 1, 2, 3, 4, 5, 6 and 9MAP, W_2 = atrazine 2.0kga.i./ha (P.E) + dimethametryne 3.0kga.i./ha (P.E) + Supplementary hoe - weeding at 2, 4, 5, 6 and 9MAP and W_3 = Diuron 2.0kga.i./ha (P.E) + supplementary hoe-weeding at 2, 4, 5, 6 and 9MAP were the sub plot. The trial was conducted on the same field for three years following the farmers practice. Each of the treatment was supplemented with half 60kgN/ha - 13kgP/ha - 18.7kgK/ha of the recommended inorganic fertilizer rate applied at six months after planting when the influence of the residual was diminishing. Each treatment was accommodated in a plot area of 15m^2 (5 x 3m) and each plot contained 6 rows of chewing sugarcane. Bida Local was the chewing sugarcane variety that was used for the experiment. Air dried cattle dung was incorporated into the soil manually using short handle hoe a month before establishing the trial. While the inorganic fertilizer was applied split at planting (½N - ½P - ½K base application) and at 6MAP during earthing up half ½N - ½P - ½K was applied. Pre-emergence herbicides were applied a day after planting, while the post - emergence was applied at 5 weeks after planting (WAP). Herbicides were applied using knapsack (CP_3) sprayer in a spray volume of 250L/ha. The supplementary hoe - weeding was carried out at 2, 4, 5, 6 and 9MAP using short handle hoe. Harvesting was done at 10MAP using cutlass. The sugarcane stalks from the net plot were tied into bundles and weighed on 50kg scale.

Table 1: Physico-chemical characteristics of soil taken from the experimental site before the establishment of the trial

Soil properties 0 - 25cm depth	Badeggi 2004
Physical properties	
Sand (%)	91.00
Silt (%)	8.00
Clay (%)	1.00
Textural class	Sandy
Chemical properties	
pH in water	6.2
Organic carbon (gkg^{-1})	0.50
Organic matter (gkg^{-1})	1.10
Total nitrogen (gkg^{-1})	0.039
Available phosphorus (mgkg^{-1})	8.95
Exchangeable cat ion(cmolkg^{-1})	
K	0.35
M_g	0.29
C_a	1.00
N_a	0.16
CEC	5.85

Table 2: Laboratory analysis of cattle dung component

	Percent (%) 2004-2007
Nitrogen	0.314
Phosphorus	0.26
Potassium	0.34
Organic	16

Source: Cow dung from the cow market behind Gwadebe New Market – Bida, Niger State, Njgeria

The Data Collected Includes

Determination of Soil Nutrient Status: Soil samples were collected using a soil auger at the establishment of the first experiment in 2004 from four different randomly selected spots and subsequently, soil samples collections were after harvest per treatment for three years from the soil depth of 0-25cm to determine the physico-chemical properties of the soil.

Particle Size Analysis: Particle size distribution was analysed by using hydrometer and textural class was determined by the soil textural triangle.

Soil pH: Soil pH was determined in water by using a soil solution ratio of 1:2.5 by means of a Philip analogue pH meter.

Total Nitrogen: The nitrogen content of the soil was determined by Macro Kjeldahl procedure [14].

Available Phosphorus: Available phosphorus was determined by Trough method. The extracted phosphorus was determined by the molybdate blue colour method [14].

Exchangeable Base: The exchangeable bases, calcium (C_a) magnesium (M_g) potassium (K) and Sodium (N_a) were extracted using IN acetate (pH 7.0).

Percent Organic Carbon: This was determined using Walkley - Black method [15].

Percent Organic Matter: This was determined by multiplying product of organic carbon with 1.724, $\%O_m = OC \times 1.724$.

Cat Ion Exchange Capacity (CEC): Cat ion exchange capacity was determined by ammonium saturation method using IN ammonium acetate (pH 7.0) saturation followed the displacement of the absorbed ammonia.

The Growth and Yield Parameters Taken Include the Following: Weed cover score 9MAP: The weed cover score was collected using score scale of 0 - 10, 0 = clean, weed free plot, 10 = weedy plot, completely weed cover. Weed dry matter production ton/ha 9MAP, Crop, vigour score 9MAP. Crop vigour score was collected using score scale of 0 - 10, 0 = silky, diseased plants, 10 = healthy, very greenish plant. Stalk length 9MAP, number of chewable stalks per plot 10MAP, Stalk girth (cm) 10MAP, tiller count per plot 3MAP and stalk yield (ton/ha).

Analysis of Data: All data obtained during the experiment was subjected to statistical analysis to test treatment effects for significance using 'F' test as described by Snedecor and Cochran [16]. Where the 'F' test showed significance, the means were compared using Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Table 3 shows the residual chemical properties of the soil before planting, all the plots treated with combined fertility rates had significantly greater values of N, P, K, organic matter and C E C than the separate application of cattle manure and inorganic fertilizer. However, the least value was obtained from the untreated control followed by the separately applied inorganic and organic fertilizer).The higher values of soil chemical properties been obtained from the plots treated with combined application of cattle dung and inorganic fertilizer may be attributed to cattle dung which might had improved the sandy structure of the experimental site, hence the leaching of the mineral N,P &K added was prevented thereby making the residual nutrients more available. Effect of weed control treatments on soil chemical properties was not significant as weed treatments could neither add nutrients nor improves the soil structure.

The soil residual nutrients from the application of main had a significant effect on weed growth parameters and stalk yield of sugarcane(Tables 4 and5). Plots treated with combined application of cattle manure with inorganic fertilizer at all rates resulted in better performance of weeds, sugarcane growth parameters and yield than plots treated with separate application of 10t/ha cattle manure and 120kgN/ha - 26kgP/ha -37kgK/ha. Pal *etal.* [17] earlier stated that soil with high residual fertility influences the severity of weeds and also improves the crop performance than soil with low nutrient level. Similarly Rhoadesre [18] earlier reported that the difference in performance of weed, crop growth and stalk yield of sugarcane was based on the rate of residual nutrients and the quantity supplemented. The application of herbicides, hoe – weeding and weedy check gave uniform non-significant weed control, sugarcane growth parameters and stalk yield (Tables 4 and 5).

Table 3: Residual soil chemical properties per treatment before planting of sugar cane at Badeggi, 2004- 2007

Treatments	Total N(gkg^{-1})	Available P($mgkg^{-1}$)	Exchangeable K($cmolkg^{-1}$)	OM (gkg^{-1})	CEC ($cmolkg^{-1}$)
Fertility rates (F)					
0(Control no cattle manure and inorganic fertilizers)	0.019e	2.31f	0.22d	0.39f	2.78e
120kgN/ha – 26kgP/ha – 37kgK/ha	0.19d	48.45d	1.24c	1.20e	9.43d
10ton/ha air dried cattle manure	0.46c	35.34c	1.37c	2.42d	14.88c
10 ton/ha air dried cattle manure + 120kgN/ha – 26kgP/ha -37kgK/ha	1.30a	64.10a	2.60a	4.05a	26.32a
10ton/ha air dried cattle manure + 60kgN/ha – 13kgP/ha – 18.7kgK/ha	1.09b	56.42b	2.30b	3.6b	26.30a
5ton/ha air dried cattle manure +120kgN/ha – 26kgP/ha – 37kgK/ha	1.28a	57.10b	2.36b	2.78c	17.59b
5ton/ha air dried cattle manure +60kgN/ha – 13kgP/ha – 18.7kgK/ha	1.00b	51.10c	2.28b	2.57c	17.52b
SE (+)	0.013	0.551	0.093	0.1	0.143
Chemical weed control treatments (C)					
Diuron 2.0kga.i/ha + dimethametryn 3.0kga.i./h + hoe weeding at 3, 6 and 9 MAP	0.099	32.39	1.35	1.14	6.49
Atrazine 2.0kga.i./ha + dimethametryn 3.0kga.i./ha + hoe weeding at 3, 6 and 9 MAP	0.099	33.4	1.35	1.13	6.49
Hoe weeding 1, 2, 3, 4, 5, 6, and 9 MAP	0.099	32.4	1.35	1.13	6
Weedy check	0.094	33.64	1.3	1.16	6.99
SE (+)	0.05	0.52	0.19	0.03	0.21
Interaction					
F X H	NS	NS	NS	NS	NS

NSN = Nitrogen, P = Phosphorus, K = Potassium, OM = Organic Matter,

CEC = Cation Exchange Capacity

Table 4: Residual effect of fertility rates and weed control treatments on weed and growth parameters of chewing sugarcane at Badeggi, 2007

Treatments	Weed cover score 3MAP	Germination count 1MAP	Tiller count /Plot 3MAP	Plant height (cm) MAP	No of chewable /plot 6MAP	Stalk girth (cm) 6MAP
Fertility rates (F)						
0(Control no cattle manure and inorganic fertilizers)	2.3	40.8	20.9	101.0.1	2.0	0.98
120kgN/ha - 26kgP/ha - 37kgK/ha	3.1	48.7	30.8	123.8	28.8	1.2
10ton/ha air dried cattle manure	3.5	49.4	38.9	129.7	32.6	1.2
10ton/ha air dried cattle manure +120kgN/ha - 26kgP/ha - 37kgK/ha	4.7	60.5	50.7	147.9	41.8	1.3
10ton/ha air dried cattle manure +60kgN/ha - 13kgP/ha - 18.7kgK/ha	4.6	59.2	48.8	146.8	40.6	1.6
5ton/ha air dried cattle manure +120kgN/ha - 26kgP/ha - 37kgK/ha	4.7	58.0	48.6	147.3	40.5	1.5
5ton/ha air dried cattle manure +60kgN/ha - 13kgP/ha - 18.7kgK/ha	4.5	57.8	47.9	146.8	40.4	1.6
SE(±)	0.10	2.10	2.47	2.75	2.80	0.040
Chemical weed control treatments (C)						
Diuron 2.0kga.i./ha + dimethametryn3.0kga.i./ha						
+ hoe weeding at 3, 6 and 9MAP	2.1	43.1	35.0	123.7	29.0	1.1
Atrazine 2.0kga.i./ha + dimethametryn3.0kga.i./ha						
+ hoe weeding at 3, 6 and 9MAP	2.2	43.9	35.1	123.6	29.8	1.1
Hoe weeding 1, 2, 3, 4, 5, 6 and 9MAP	2.1	43.8	35.0	124.8	28.8	1.1
Weedy check	3.9	31.9	30.0	120.0	25.8	1.0
SE(±)	0.30	1.8	1.8	0.96	1.99	0.03
Interaction						
F X H						

F = Fertility, C = Chemical weed control, MAP = Months after planting

Table 5: Residual effect of fertility rates and weed control treatments on yield and yield attributes of chewing sugar cane at Badeggi, 2008

Treatments	Stalk girth (cm) 12MAP	Stalk length (cm) 12 MAP	Number of chewable stalks/plot 12 MAP	Brix % 12 MAP	Stalk yield (t/ha) 12 MAP
Fertility rates (F)					
(Control no cattle manure and inorganic fertilizer)	2.11b	118.18c	30.08c	16.2	29.19c
120kgN/ha–26kgP/ha37kg/ha	2.30b	121.00c	32.25c	16.2	31.78c
10t/ha air dried cattle manure	3.07b	143.73b	59.58b	16.4	58.76b
10t/ha air dried cattle manure + 120kgN/ha-26kgP/ha-37kgK/ha	4.39a	168.12a	78.75a	16.44	68.76a
10t/ha air dried cattle manure + 60kgN/ha-13kgP/ha-18.7kgK/ha	4.23a	167.98a	76.17a	16.58	68.44a
5t/ha air dried cattle manure + 120kgN/ha-26kgP/ha-37kgK/ha	4.37a	164.38a	75.81a	16.48	66.20a
5t/ha air dried cattle manure + 60kgN/ha-13kgP/ha-18.7kgK/ha	4.20a	165.00a	74.99a	16.43	65.45a
SE (+)	0.26	1.98	1.96	0.6	2.05
Chemical Weed Control Treatments (C)					
Diuron 2.0kg a.i./ha + dimethametryne 3.0 + kga.i./ha +	3.11	157.82	30.3	16.1	28.91
hoe weeding at 3, 6 & 9 MAP					
Atrazine 2.0kg a.i./ha + dimethametryne 3.0kga.i./ha +	3.12	156.85	29.69	16.1	29.01
hoe weeding at 3, 6 & 9 MAP	3.1	155.31	29.41	16.12	29
Hoe weeding 1, 2, 3, 4, 5, 6 & 9 MAP	3.1	149.33	29.31	16.11	28.99
Weedy Check					
SE (+)	0.17	1.21	0.5	0.1	0.25
Interaction					
F x C	*	NS	*	NS	*

CONCLUSION

Through the use of cattle dung, the unproductive over mined sandy upland sugarcane experimental field of NCRI Badeggi has been made productive leading to higher increase of chewing sugarcane stalk from 60 ton / ha to between 70.63 - 76.23 ton/ha. Therefore, the use of cattle dung as a soil amendment agent could be recommended for this ecology. The residual effect was able to sustain sugar production for four months.

The residual nutrients from cattle dung combined with inorganic fertilizer (N, P & K) became necessary to be supplemented with inorganic fertilizer at the half of the recommended rate60kgN/ha - 13kgP/ha- 18.7kgK/ha as sugarcane being a long duration crop and also higher feeder. The residual from the separate application of cattle dung and inorganic fertilizer alone cannot sustain the production of sugarcane. Based on the positive influence on the sugarcane growth and yield derived from the residual of combined fertility rates and also the higher values of soil organic matter, organic carbon, cat ion exchange capacity and soil chemical properties the lowest combined fertility rate of 5 tones / ha of air dried cattle dung +60kgN/ha - 13kgP/ha - 18.7kgK/ha can be recommended being the rate that its residual nutrients could sustain sugarcane production for this ecology and similar ecologies. And being the lowest combined fertility rate that can easily be affordable by the local poor resource sugarcane farmers.

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